Update of L1 RCT Rates at $\mathcal{L}=2\times10^{33}$

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- **CMS Internal note published CMS IN-2001/042**
  - Results obtained using old 10^{33} data - new 2×10^{33} data is available at FNAL
- **Have availble p_T's for trigger event and pileup - can calculate proper weights for the event**
- **rate calculation is more precise now (huge rate jumps have been eliminated).**

Simulation Introduction

Rates at LHC Turn On

- **Rates were calculated using new 2×10^{33} data (nTuples generated using FNAL production data)**
- ***Weighted using proper weights* - not done for November's results**
  - p_T's of main event and pileup not available for TDR analysis
  - Just learned how to get them in new ORCA 4_5_4
- **No threshold increases for missing E_T and total E_T**
- **QCD data produced at FNAL**
  - Proper 3.5 events of pileup
  - Newer versions of CMSIM and ORCA
- **Nearly 180,000 events in L1 Calo nTuples**
- **HLT p_T bins from 10-470 GeV used**

Algorithms

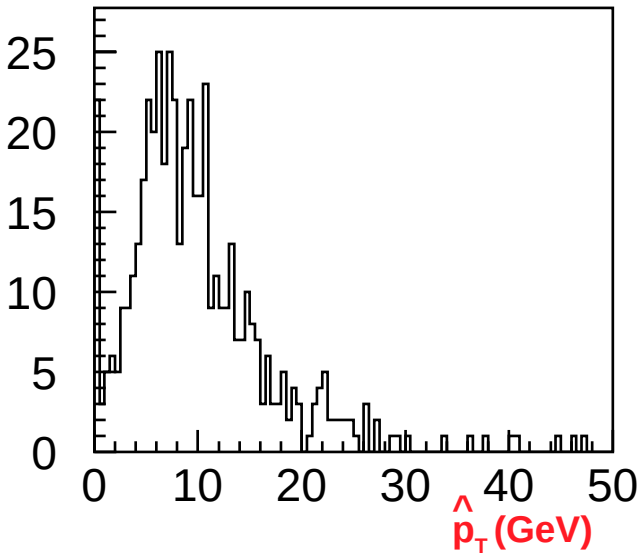
- **Only isolated electrons ($\mathcal{L}=10^{33}$ in TDR used non-iso as well)**
  - B Physics sacrificed
- **Jet algorithm: A programmable threshold cut is now applied to the center region of the 9 (3x3) regions.**
- **τ algorithm is updated to use new pattern algorithm**
- **Rates for new H_T Trigger - see following slides**

Calculation of the proper weight

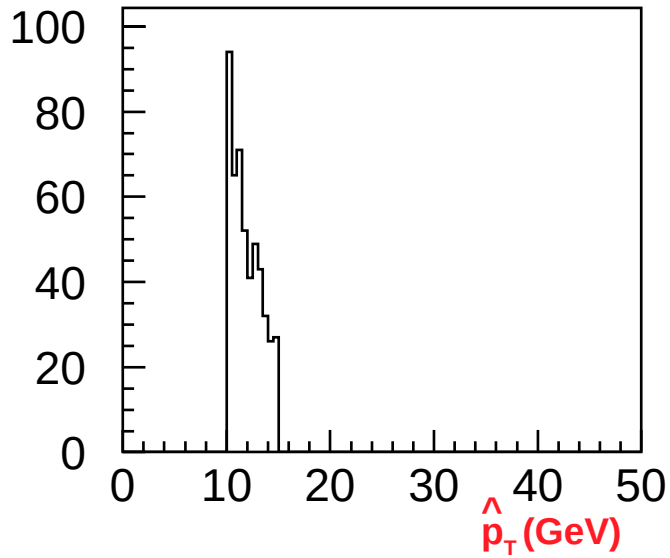
The problem:

- pileup events sometimes have a larger $\hat{p}_T$ than the actual "Physics" event in the QCD sample
- weight needs to take this into account
- Weight = $32\times10^3\mu \div \sum_{j=1}^{N_{bin}} N_j(n_j/f_j)$ (Branson and Trepagnier)
- Use pileup $\hat{p}_T$'s from bunch crossing "0".

Highest Energy Pileup Event



Physics Event

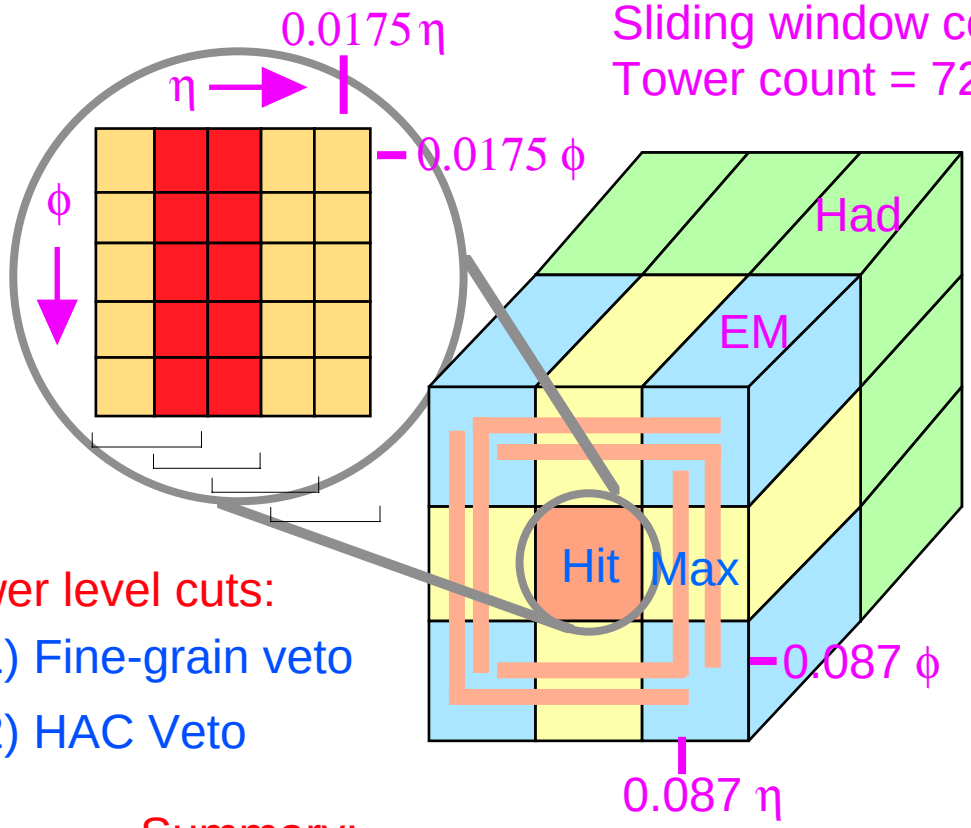


Clearly, some events' pileup has higher $\hat{p}_T$ than the physics event

November results used weights based solely on the physics event - rates were much too high!

(10-15 GeV bin - 500 events)

e/γ Algorithm - unchanged



Sliding window covering all η–ϕ plane
Tower count = 72ϕ x 56η x 2 = 8064

Candidate Energy:

- Max: Max E_t of 4 Neighbors
- Hit: Hit + Max E_t > Threshold

Tower level cuts:

1) Fine-grain veto
2) HAC Veto

Isolation Cuts:

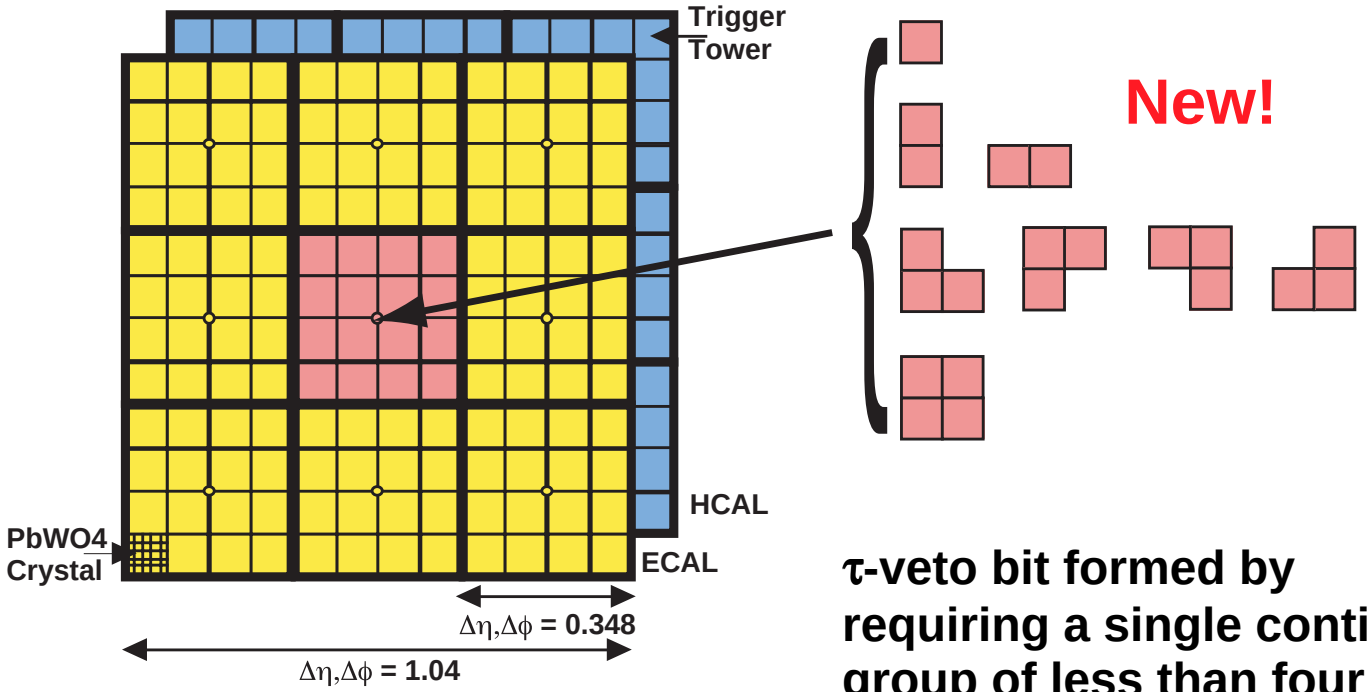
3) Neighbor FG/HAC Veto
4) Neighbor EM E_t Veto

Summary:

Sort over all (η,ϕ) plane to find top-4 isolated and non-isolated candidates separately.

Jet/τ Algorithm

Input from E/HCAL: Programmable 8-bit nonlinear scale converted to 10-bit linear scale for sums to obtain jet E_T



τ-veto bit formed by requiring a single contiguous group of less than four active towers in each 4x4 region

Jet or τ E_T

- 12x12 trigger tower E_T sums in 4x4 region steps with central region > others,
- *central region above a programmable threshold (5 GeV for this study).*

τ algorithm

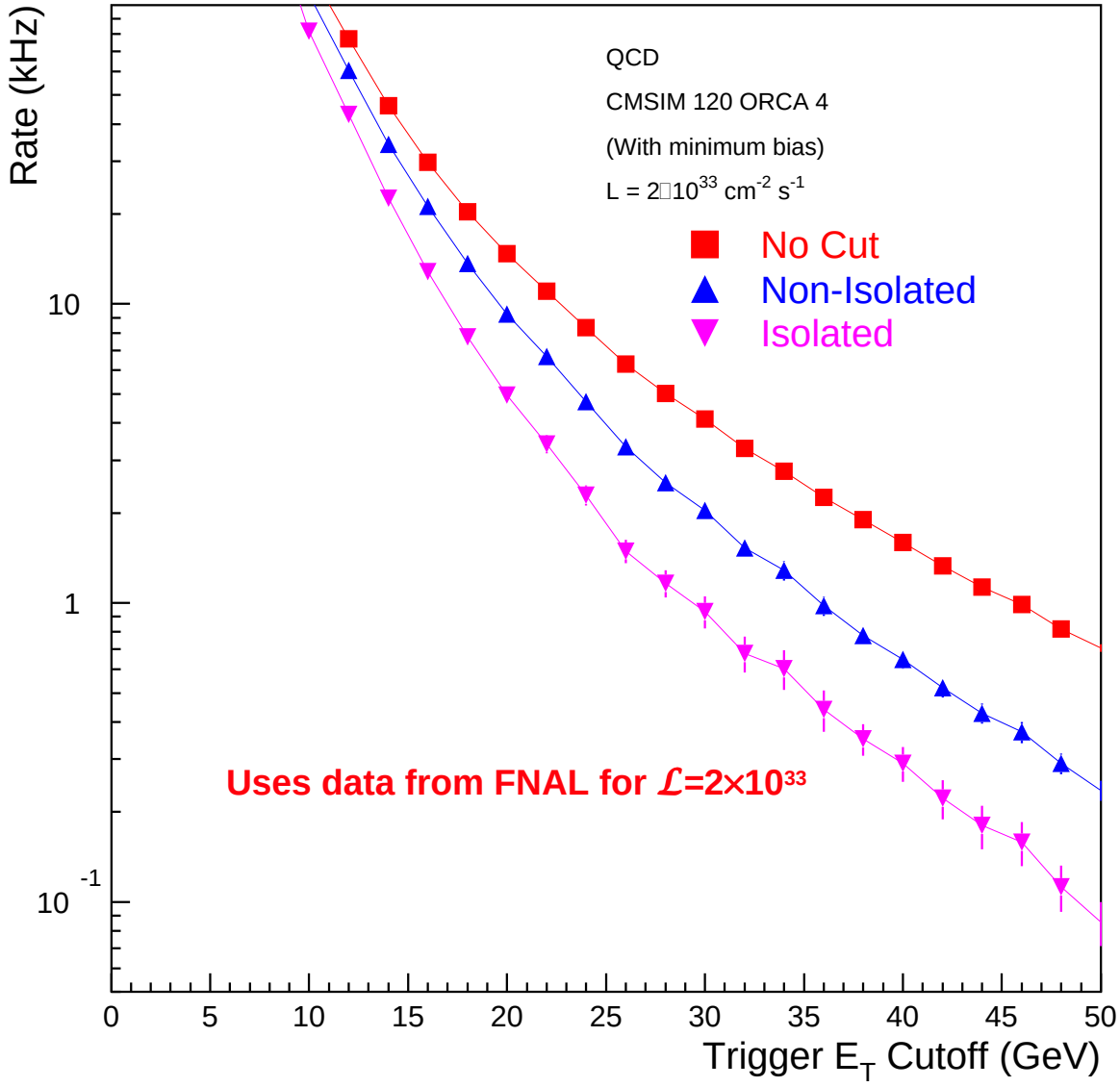
- redefine jet as τ-jet if none of the nine 4x4 region τ-veto bits are on

Output

- top 4 τ-jets and top 4 jets in central rapidity, and top four jets in forward rapidity

Updated e/γ rates

Low Luminosity e/γ trigger rates



Single e/γ at 27 GeV cutoff: 1.3 kHz

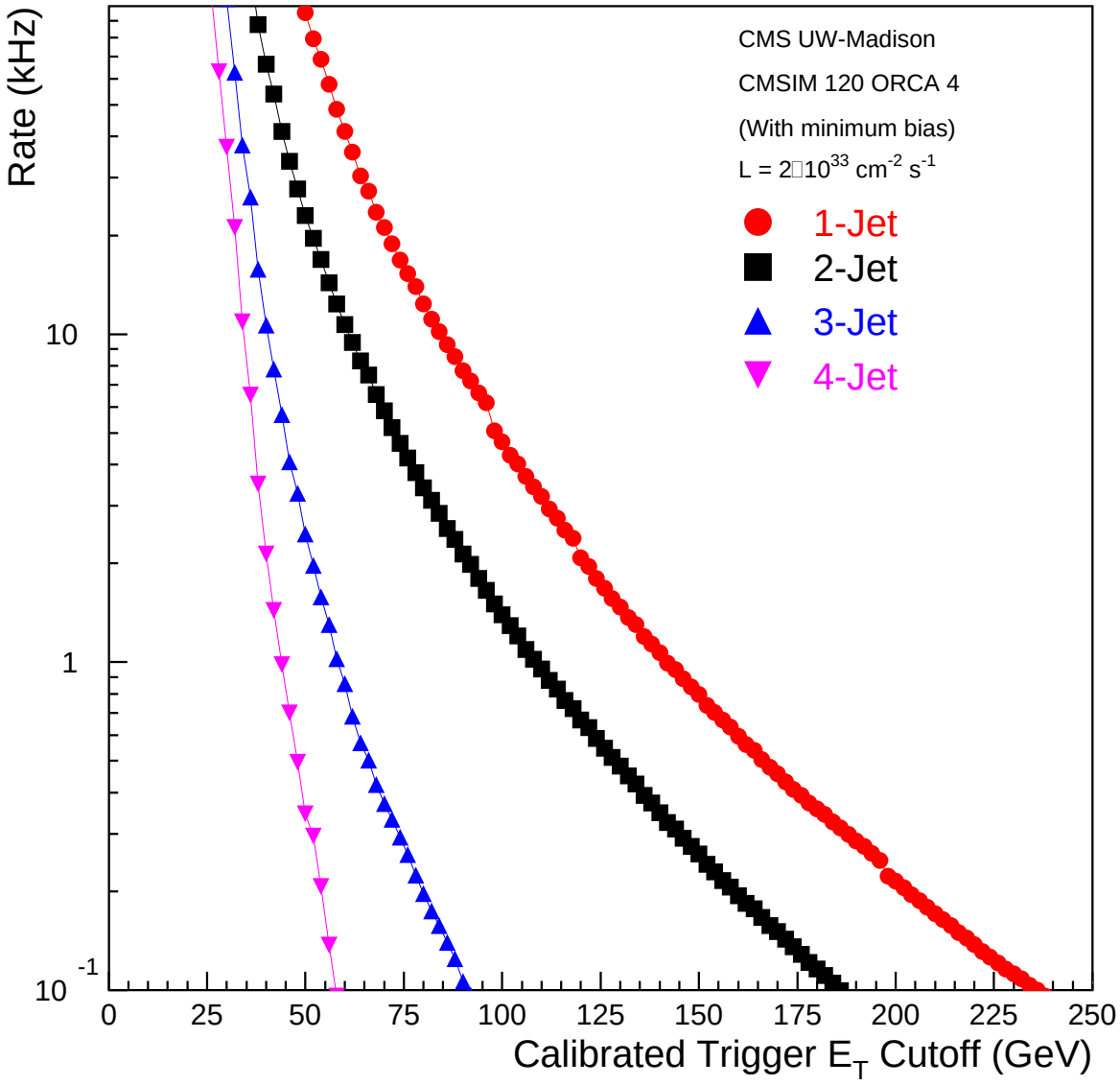
Single e/γ rate from previous study →2.6 kHz (November)

Single e/γ rate from Internal Note →1.7 kHz (used old 10^{33} data)

Rates compared to November result are halved with proper weighting! Consitent with TDR result for low luminosity.

Updated Jet Rates

Low Luminosity Jet Trigger Rates (|η|<5)



Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

Single jet at 120 GeV: 2.1 kHz
Di-jet at 90 GeV: 2.0 kHz

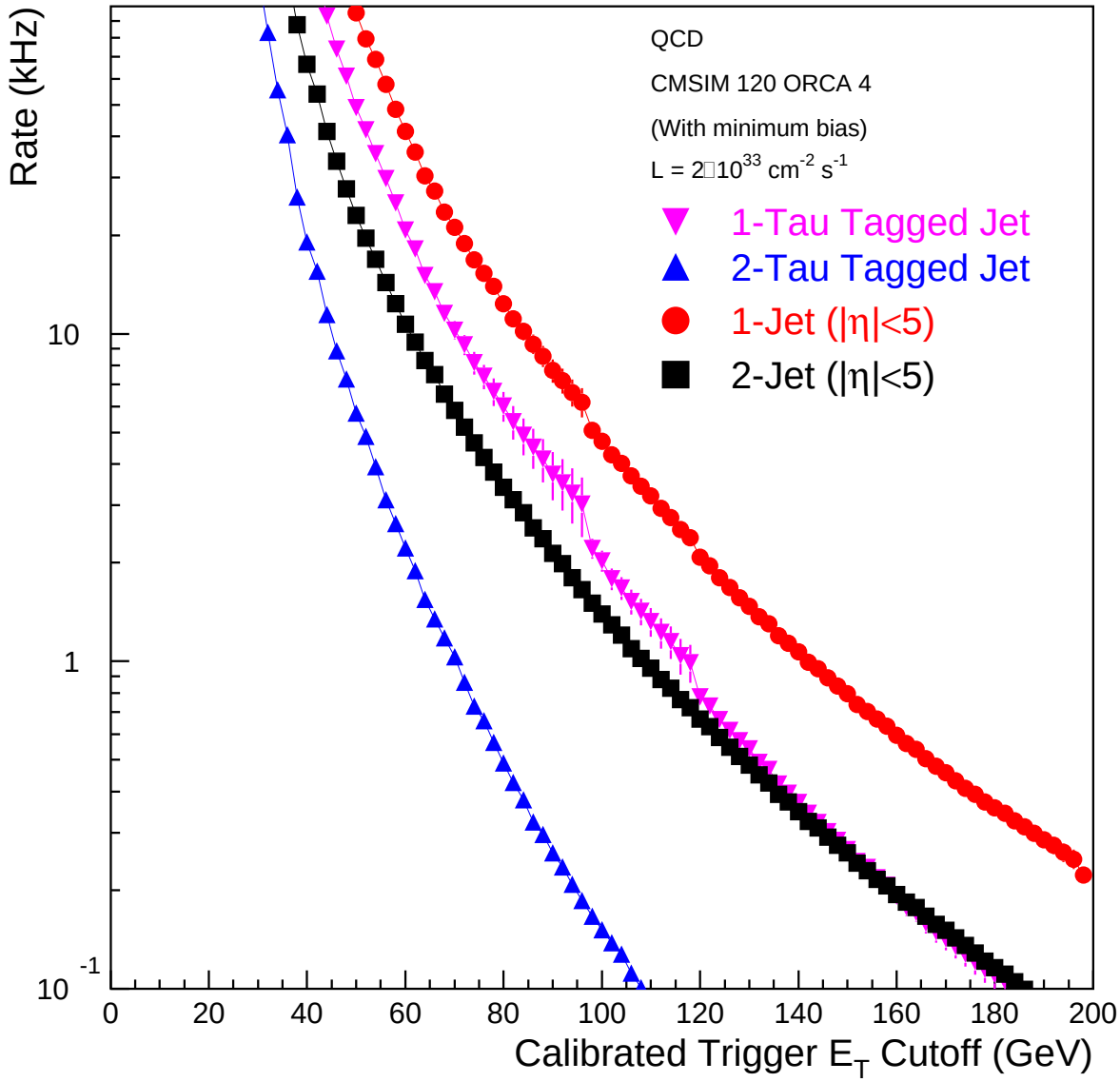
Previous Study (November):
3.0 and 4.0 kHz

Internal Note w/10^{33} data weighted to 2×10^{33}:
2.4 and 2.0 kHz

Much smoother rate curves and lower rates vs. November result

Changes in τ Rates

Low Luminosity Tau and Jet Trigger Rates



Single τ at 80 GeV: 6.0 kHz
Single jet at 120 GeV: 2.1 kHz
Using new τ trigger!

Previous Study (Nov.):
Single τ at 80 GeV: 10.3 kHz
Single jet at 120 GeV: 3.0 kHz

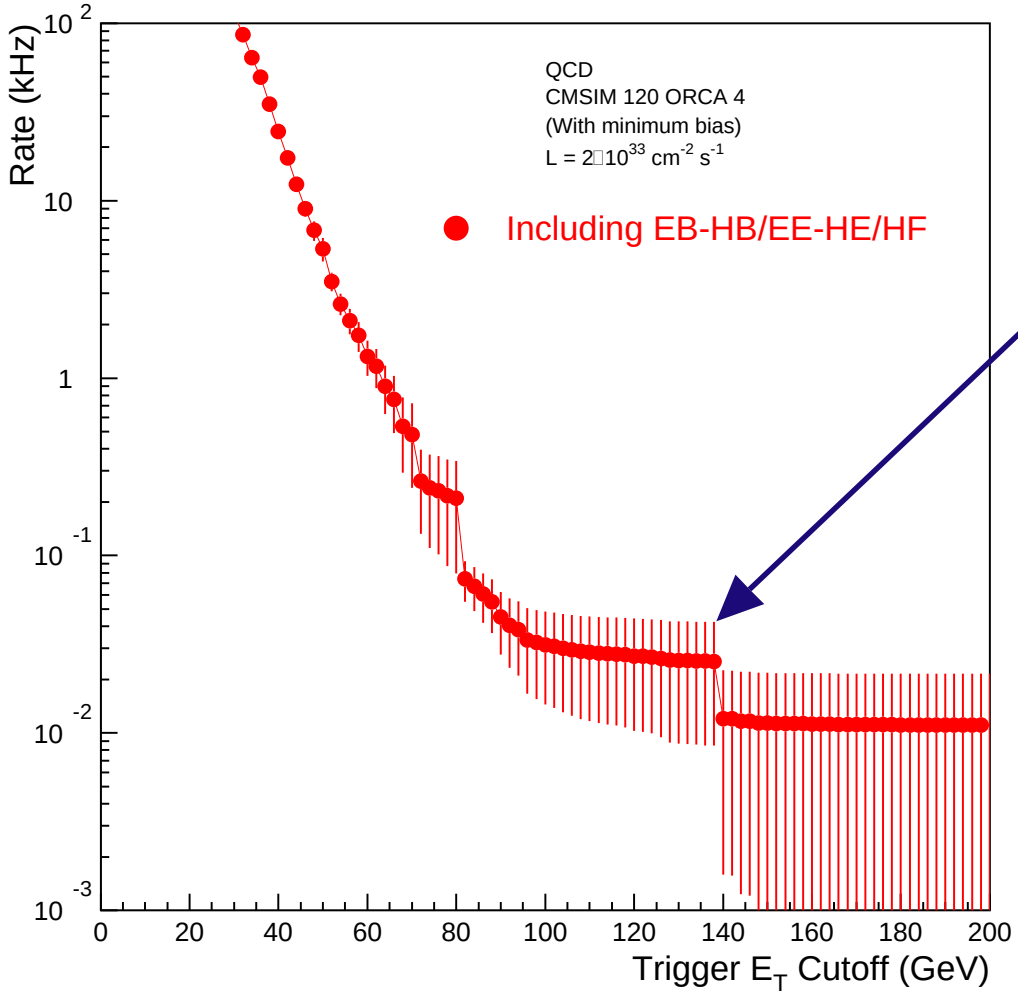
Note w/10^{33} data weighted to 2×10^{33}:
Single τ at 80 GeV: 6.5 kHz
Single jet at 120 GeV: 2.4 kHz

Single τ rate smoother, rates lower than both November's and the results from the note.

Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

Rate of Missing E_T

Missing E_T trigger rate



Strange behavior here is from outliers in higher $\hat{p}_T$ bins, i.e. greater than 10-15

Rate ~0.01-0.03

No real changes in rate vs. previous results. TDR at 0.01 kHz for 10^{33}

Missing E_T at 100 GeV: 0.03 kHz

Note w/10^{33} data weighted to 2×10^{33}: 0.02 kHz

Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

New Trigger "H_T"

Use all 12 jets: 4 each of central, τ, and forward

- all jets are mutually exclusive

After correcting the jet energies, sum up E_T's of all jets with energy greater than a certain threshold:

- $H_T = \sum E_{Tjet}$ E_{Tjet} > threshold energy

Advantages

- Calibrated (jet energies are calibrated)
- Simple trigger for decays of heavy objects to multiple jets

New H_T Rate

H_T=sum of all jet E_T's with E_T > some programmable threshold

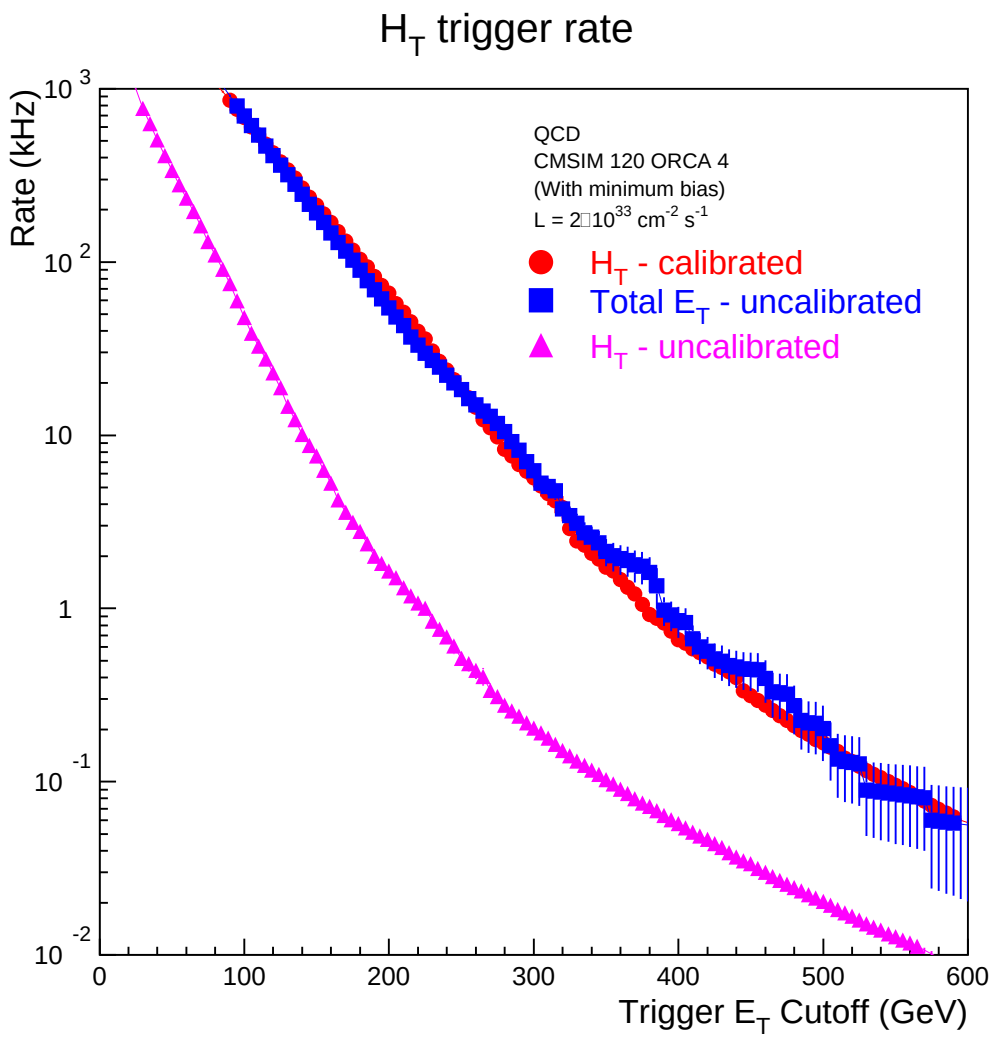
- **E_T > 10 GeV for this result**

Smoother than Novembers result, rate is also lower.

For a 400 GeV cutoff: 0.7 kHz

Previously: 1.6 kHz

Trigger's efficiency for physics channels needs to be studied.



Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

Individual and cumulative rates using new data with 2×10^{33} pileup and old 10^{33} data weighted to 2×10^{33}

New Results (kHz)		Trigger	95% or (90%) Efficiency	Previous (kHz)	
Ind.	Cum.			Ind.	Cum.
1.3	1.3	e	32	1.7	1.7
0.4	1.7	ee	19	0.5	2.1
6.0	7.5	τ		6.5	8.3
1.4	7.8	ττ		1.9	9.0
2.1	8.9	j	150	2.4	10.2
2.1	9.2	jj	115	2.0	10.5
0.4	9.2	jjj	95	0.7	10.5
0.3	9.4	jjjj	75	0.7	10.8
0.4	9.5	e·jet	14&125	0.6	10.9
1.8	10.3	e·t		2.3	11.7
0.03	10.3	Missing ET	(275)	0.02	11.7
0.2	10.4	e·MET	(12&175)	0.1	11.7
3.1	12.0	j·MET	(65&175)	1.3	12.5
0.2	12.2	Total ET	(1000)	0.04	12.4
22.1		Total before HT		12.4	
0.7	12.2	Total After HT		N/A	

Cutoffs from CMS IN-2001/042*

Overall rate remains about the same as result from Internal note.

j•MET is higher than Internal note result of 1.3 kHz, but half of November's result of 6.6 kHz

Previous results use older 10^{33} data (*Note)

→Rates look good with new weighting (Nov. result: 22.6 kHz!)

Efficiencies for Selected Physics Channels

Numbers are preliminary.

Some triggers are lower - a bug found in our nTuple Generator was not zeroing the jet energies properly.

Some will benefit from H_T trigger - needs study.

Channel	Eff.	Triggers
W→eν	53%	e
Z→ee	91%	e,ee
H(200)→ττ→jj	91%	τ,ττ,j,jj
H(500)→ττ→jj	99%	j,jj,τ,ττ
mSUGRA (point 3)	99%	j,jj,jjj,jjjj
t→jets	75%	jjjj,jjj,jj,j,τ
t→eX	89%	e•τ,jjjj,e•j,τ,e
Charged higgs, M=200 GeV	99%	j,jj,τ,jjj
Invisible higgs	51%	j•MET,j,MET,jj

Summary

Rates of old 10^{33} data weighted as 2×10^{33} and new 2×10^{33} using proper weighting are similar

- **No noticeable rate changes due to changes in algorithms**
- **Proper weighting dramatically reduces rates**
  - p_T's of pileup events were greater than QCD physics event.
- **Results are consistent with earlier TDR results**
- **CMSIM Loss = 2 still needs to be explored**

Studies will be made with 2×10^{33} data available at FNAL or by production at Wisconsin

- **retune thresholds for different DAQ staging scenarios of 12.5, 10, 8, 6, and 4 kHz**
- **optimize for physics performance**
- **Study the new τ and H_T triggers in more detail**
- **produce updated second $\mathcal{L}=2\times10^{33}$ note before New Year**
- **Current Note: CMS IN-2001/042**